CLAIMS

Having described the invention, we claim:

1. A tube fitting for metal tubing, comprising:

a) a body and nut that can be joined; said body having an interior bore that is adapted to receive a metal tube end along a central longitudinal axis of the fitting; said bore having a camming surface at one end of said bore;

b) said nut having a ferrule drive surface; and

c) a ferrule having a front end and a back end; said ferrule back end having a ferrule driven surface engaging said nut ferrule drive surface when the fitting is pulled up; said ferrule front end engaging said camming surface to form a seal; said ferrule having a central bore formed by a substantially continuous cylindrical interior wall closely received over the tube end during assembly;

d) wherein said camming surface forms an included angle of at least about thirty-five degrees to about sixty degrees with respect to said longitudinal axis.

2. The tube fitting of claim 1 wherein said ferrule front end engages said camming surface to form a metal to metal primary seal.

3. The tube fitting of claim 2 wherein said ferrule plastically deforms with a hinging action that produces a radial compression in a central portion of said ferrule against said tube end.

4. The tube fitting of claim 3 wherein said ferrule front end forms a generally narrow line contact seal against said camming surface.

5. The tube fitting of claim 1 wherein said ferrule driven surface is convex.

6. The tube fitting of claim 1 wherein said ferrule front end indents into an outer surface of the tube end to form a shoulder that contacts said front end; said ferrule having a substantially cylindrical interior bore portion that is adjacent said front end; said bore portion being radially compressed into the tube end upon completing an initial pull-up of the fitting.

7. The tube fitting of claim 6 wherein said radial compression of said bore portion is convex and produced by a hinging action of said front end during pull-up.

8. The tube fitting of claim 1 wherein said ferrule back end is radially spaced from the tube end after a completed initial pull-up of the fitting.

9. The fitting of claim 1 wherein said ferrule is at least at about 3.3 times ~~on~~ on the vickers scale ~~harder than~~ hardness of the tube end.

10. The fitting of claim 9 wherein said ferrule driven surface is convex.

11. The fitting of claim 1 wherein said ferrule comprises an outer wall having a concavity that facilitates radial compression of a portion of said cylindrical interior wall against the tube end.

12. The fitting of claim 11 wherein said radially compressed portion collets said ferrule onto the tube end axially behind said ferrule front end.

13. The fitting of claim 1 wherein a portion of said ferrule front end indents into the tube end upon pull-up.

14. The fitting of claim 1 wherein said ferrule driven surface engages said ferrule drive surface of said nut at a difference angle therebetween so that said ferrule back end is radially spaced from the tube end after a complete pull-up.

15. The fitting of claim 1 wherein said ferrule plastically deforms during pull-up with a hinging operation wherein a forward portion of the ferrule rotates in a first direction so that a front edge thereof is radially compressed inward to indent into the tube end with a central portion of the ferrule colleting the tube end behind the indented front edge, and said ferrule back end rotates in an opposite direction from said first direction so as to be radially spaced from the tube end after pull-up.

16. The fitting of claim 1 wherein the tube end is at least about .5 inch diameter.

17. The fitting of claim 1 wherein said included angle is about forty degrees to about fifty degrees.

18. The fitting of claim 17 wherein said included angle is about forty-five degrees.

19. The fitting of claim 1 wherein said ferrule comprises case hardened stainless steel.

20. The fitting of claim 5 wherein said convex driven surface contacts said nut ferrule drive surface at a location that is radially spaced from the tube end.

21. The fitting of claim 20 wherein said ferrule back end is radially spaced from the tube end after the fitting is pulled-up.

22. The fitting of claim 20 wherein said convex driven surface comprises a radius portion.

23. The fitting of claim 22 wherein said convex driven surface further comprises a straight portion.

24. The fitting of claim 11 wherein said outer wall concavity is formed by an axially tapered portion and a generally cylindrical portion of said outer wall.

25. The fitting of claim 1 wherein upon pull-up said ferrule has a front end that is indented into the tube end, a back end that is radially spaced from the tube end, and a portion between said front and back ends that collets the ferrule with a convex radial compression.

26. The fitting of claim 25 wherein said ferrule is case hardened and is at least about 3.3 times harder than the tube end on the Vickers scale.

27. The fitting of claim 1 wherein said ferrule includes a front edge that indents into the tube end and a portion that is axially between said ferrule front and back ends that upon pull-up of the fitting is radially compressed against the tube end to collet said ferrule onto the tube end, said radially compressed portion having a generally increasing compression force along a length of said ferrule extending from said indented front edge of said ferrule.

28. A tube fitting for metal tubing, comprising:

a) a body and nut that can be joined; said body having an interior bore that is adapted to receive a metal tube end along a central longitudinal axis of the fitting; said bore having a camming surface at one end of said bore;

b) said nut having a ferrule drive surface; and

c) a ferrule having a front end and a back end; said ferrule back end having a ferrule driven surface engaging said nut ferrule drive surface when the fitting is pulled up; said ferrule front end engaging said camming surface to form a seal; said ferrule having a central bore formed by a substantially continuous cylindrical interior wall closely received over the tube end during assembly;

d) said ferrule driven surface being convex and initially contacting said nut ferrule drive surface at a location that is radially spaced from the tube end;

e) wherein said camming surface forms an included angle of about forty-five degrees with respect to said longitudinal axis.

29. The fitting of claim 28 wherein said ferrule back end is radially spaced from the tube end after the fitting has been pulled-up.

30. A tube fitting for metal tubing, comprising:

a) a body and nut that can be joined; said body having an interior bore that is adapted to receive a metal tube end along a central longitudinal axis of the fitting; said bore having a camming surface at one end of said bore;

b) said nut having a ferrule drive surface; and

c) a ferrule having a forward portion and a back end; said ferrule back end having a ferrule driven surface engaging said nut ferrule drive surface when the fitting is pulled up; said ferrule forward portion including a front end that engages said camming surface to form a seal; said ferrule having a central bore formed by a generally continuous cylindrical interior wall closely received over the tube end during assembly;

d) said ferrule front end including a front edge that indents into the tube end, said ferrule having a portion of said generally cylindrical interior wall radially compressed in a location axially behind said indented front edge with a compressive stress that decreases in a generally axial direction away from said indented front edge.

31. A tube fitting for metal tubing, comprising:

a) a body and nut that can be joined; said body having an interior bore that is adapted to receive a metal tube end along a central longitudinal axis of the fitting; said bore having a camming surface at one end of said bore;

b) said nut having a ferrule drive surface; and

c) a ferrule having a forward portion and a back end; said ferrule back end having a ferrule driven surface engaging said nut ferrule drive surface when the fitting is pulled up; said ferrule forward portion including a front end that engages said camming surface to form a seal; said ferrule having a central bore formed by a cylindrical interior wall closely received over the tube end during assembly;

d) said ferrule driven surface being convex, said ferrule being at least about 3.3 times harder than the tube end, said camming surface forming an included angle of at least about thirty-five degrees to about sixty degrees with respect to said longitudinal axis, said ferrule cylindrical interior wall being radially compressed against the tube end axially behind said ferrule front end.

32. The tube fitting of claim 31 wherein said ferrule comprises an outer wall having a concavity that facilitates said radial compression of said cylindrical wall portion behind said front end.

33. The tube fitting of claim 31 wherein said ferrule is case hardened.

34. A tube fitting for metal tubing, comprising:

a) a first fitting component and a second fitting component that can be joined; said first fitting component having an interior bore that is adapted to receive a metal tube end along a central longitudinal axis of the tube fitting; said bore having a camming surface at one end of said bore;

b) said second fitting component having a ferrule drive surface; and

c) a single ferrule having a front end and a back end; said ferrule back end having a ferrule driven surface engaging said second fitting component ferrule drive surface when the fitting is pulled up; said ferrule front end engaging said camming surface to form a seal; said ferrule having a central bore formed by a generally cylindrical interior wall closely received over the tube end during assembly; having a ratio of the hardness of

d) said ferrule being at least about 3.3 times ~~harder than~~ the tube end on the Vickers scale, said ferrule plastically deforming during pull-up with a hinging action that causes a portion of said generally cylindrical interior wall to be radially compressed against the tube end axially behind said ferrule front end to collet said ferrule onto the tube end.

35. The tube fitting of claim 34 wherein said portion of said cylindrical interior wall that is radially compressed forms a convex profile upon pull-up.

36. The tube fitting of claim 34 wherein said camming surface is about forty degrees to about fifty degrees and said driven surface is convex.

37. The tube fitting of claim 34 wherein said ferrule back end is radially spaced from the tube end after pull-up of the fitting.

38. The tube fitting of claim 37 wherein said ferrule back end comprises an interior counterbore.

39. The tube fitting of claim 34 wherein said cylindrical interior wall is substantially continuous along its entire axial length.

40. The tube fitting of claim 39 wherein said ferrule back end comprises an interior counterbore.

41. The tube fitting of claim 34 wherein said cylindrical interior wall comprises a radial recess that is axially spaced from a front edge of said ferrule.

42. The tube fitting of claim 34 wherein said ferrule comprises an axially tapered outer wall.

43. The tube fitting of claim 34 wherein said ferrule comprises an outer wall having a concavity between said front and beck ends to facilitate said hinging action.

44. The tube fitting of claim 34 wherein said first and second components are joined by a threaded connection.

45. The tube fitting of claim 44 wherein said threaded connection comprises buttress threads.

46. The tube fitting of claim 44 wherein said threaded connection comprises acme threads.

47. The tube fitting of claim 34 wherein said ferrule driven surface and said second component ferrule drive surface form a difference angle therebetween when said surfaces initially meet during assembly of the fitting.

48. The tube fitting of claim 47 wherein said difference angle is such that said drive surface contacts said driven surface at a location that is radially spaced from the tube end.

49. The tube fitting of claim 34 wherein said ferrule front end forms an angle α with the surface of the tube end, said angle being about three to about five degrees from normal.

50. In a flareless tube fitting of the type having a first fitting component threadably joinable to a second fitting component, with at least one ferrule contained within a cavity defined by the joined components, the improvement comprising said threaded connection having buttress threads.

51. In a flareless tube fitting of the type having a first fitting component threadably joinable to a second fitting component, with at least one ferrule contained within a cavity defined by the joined components, the improvement comprising said threaded connection having acme threads.

52. The tube fitting of claim 28 wherein said ferrule plastically deforms during pull-up with a hinging action that collets the ferrule onto the tube end.

53. A tube fitting for metal tubing, comprising:

a first fitting component and a second fitting component that can be joined together along a central axis of the fitting; said first and second fitting components being made of metal;

said first fitting component comprising a bore that slideably receives a tube end and a tapered camming surface at one end of said bore;

said second fitting component having a tube gripping device that is integrally attached thereto and that engages said camming surface when the fitting is made up.

54. The tube fitting of claim 53 wherein said tube gripping device extends in a cantilevered manner from a portion of said second fitting component.

55. The tube fitting of claim 53 wherein said first and second components comprise stainless steel.

56. A metal fitting component for a flareless metal tube fitting, comprising:

a main metallic body having a central bore therein; and

a metallic tube gripping device that is integrally attached to said main body and extends into said central bore.

57. The tube fitting of claim 55 wherein said tube gripping device extends in a cantilevered manner from a portion of said main body.

58. The tube fitting of claim 56 wherein said tube gripping device functions as a ferrule.

59. The tube fitting of claim 34 wherein said ferrule is case hardened over part or all of its surface.

60. The fitting of claim 31 wherein said cylindrical interior wall comprises a circumferential radial recess.

61. The fitting of claim 31 wherein said cylindrical interior wall is substantially continuous along substantially its entire axial length.